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THE NOVO REPORT: AMERICAN ATTITUDES AND BELIEFS ABOUT GENETIC ENGINEERING

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PREFACE

PREFACE

As the world's largest producer of industrial enzymes and one of the world's largest manufacturers of insulin, Novo Industri A/S has long been committed to the socially responsible use of biotechnology. Biotechnology is a rapidly advancing field of science which is little understood by the general public. Yet its new and developing technologies potentially will touch upon the lives of us all.

We at Novo believe that new technological advances should be made with the full knowledge of an educated public, which can weigh benefits versus costs and potential risks. The Novo Report: American Attitudes and Beliefs About Genetic Engineering was undertaken for the purpose of examining how much Americans know about one of the most essential areas of biotechnology, genetic engineering. This burgeoning field of scientific research promises to assist man in the battle against such evils as disease and crop failures. However, ethical questions do arise when man intervenes with the "natural order." It is for this reason that Novo is committed to increasing public awareness of some of the issues involved in this and other areas of biotechnology. The Novo Report is only one step in helping to broaden public knowledge about a science that may significantly effect the quality of human life.

Throughout its history, Novo has sought to benefit society through the introduction of high quality products in both the health care and industrial sectors. Our commitment to the effort of furthering public understanding of biotechnology is a reflection of Novo's philosophy of utilizing the resources of private industry for the good of the public.

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OVERVIEW

Genetic engineering is a science about which the American public has little knowledge, but which holds the potential to dramatically affect human life in the decades to come. Moreover, genetic engineering raises moral and ethical issues which are complex and, in the minds of some, difficult to resolve. Who in our society will be responsible for making decisions about the use of genetic engineering, and what role, if any, should the public play?

The degree to which scientists should be free to release genetically altered material into the environment as part of their research efforts has recently become a highly debated issue. If the public is to make any fair assessment of issues such as this, a degree of understanding of the risks and benefits involved in genetic engineering is necessary. This science is still strictly regulated by government agencies, but recent calls for a slackening of regulation have made the need for public education a matter of some urgency. The problem has become a subject of major news coverage and editorial comment -- in some cases calling for less regulation, in others calling for more, but all consistently expressing a need for greater public knowledge.

A recent Wall Street Journal editorial protested the stringent U.S. regulations, saying that American scientists "have already taken their work overseas, fleeing the U.S.'s mania for overregulating." An editorial in the New York Times warned

against slackening of control, proclaiming that, "The rate and risks of progress are matters for society to decide." The Novo Report: American Attitudes and Beliefs about Genetic Engineering probes whether society is indeed well enough informed to participate in the decision-making process, and if not, what can be done to raise the public's level of awareness and understanding.

This report was undertaken for the purpose of examining how much Americans really know about this relatively new science and how they feel about its potential applications. As a secondary component of the study, these findings were presented to 29 scientists and ethicists from universities around the country.* Their comments on the level of public knowledge and on the safety and potential benefits/dangers of genetic engineering are presented in Chapter 5 of the report.

Public Understanding of Genetic Engineering

Perhaps one of the most important findings of The Novo Report is the lack of knowledge among the American public about some of the critical issues surrounding genetic engineering. Two in five (39%) members of the public had not heard of genetic engineering. These individuals were disqualified from participating in the survey. Among those who had heard of the science, two in three (66%) say that they personally do not understand the moral and

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* A list of these scientists and ethicists is given in the the methodology section.

ethical issues of gentic engineering well enough to take a firm position on how it should be regulated. This means that roughly four in five Americans either don't know what genetic engineering is or don't know enough about the science to understand the ethical issues involved.

Scientists and ethicists themselves express widely varying opinions about which aspects of genetic engineering do indeed raise moral questions. The most common cause for concern is the potential uses of gene therapy in humans (the introduction of new genetic material into living tissues).

Questions Raised by Gene Therapy

According to interviewed scientists and ethicists, this technology offers the potential to relieve suffering but can also pose a difficult ethical dilemma. The critical issues are whether genetic changes will affect only the individual treated or will be passed on to future generations, and whether they are being introduced for disease prevention or to "improve" the species.

Although a large percent of the sampled public do not understand the ethical issues involved in genetic engineering, a majority express general support for various types of gene therapy. Three-quarters (75%) support the concept of preventing hereditary diseases by changing some of the genes in a woman's egg cells, or in a man's sperm cells, so that the disease will

not be passed on to the next generation.*

Two-thirds (67%) favor the concept of curing hereditary diseases by inserting artificially altered genes into the body of an individual. Half (53%) would support the practice of curing a potential disease by inserting artificially altered genes into a fetus.

Some scientists were surprised by the strong public endorsement of inserting altered genes into a woman's egg cell or a man's sperm cell. They pointed out that this is more problematic morally and more dangerous than putting altered genes into an individual's body or into a fetus. Referring to the state of public education about this complex issue, one ethicist comments, "A little knowledge about this subject is more dangerous than no knowledge at all."

Less Controversial Aspects of Genetic Engineering

Scientists and ethicists agree that the production of drugs through the use of genetically altered bacteria, an important and promising use of the technology, presents no moral dilemma. There is also little controversy over the uses of the technology with plants.

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* This figure of 75% and all subsequent figures refer only to the 61% of the public who said they had heard of genetic engineering. As stated above, the 39% who had not heard of the science were eliminated from the sample. The percentages, therefore, do not refer to the general public, but rather to that portion of the public who are somewhat aware of genetic engineering.

Interestingly, the surveyed public is more likely to associate genetic engineering with its less controversial aspects. Nearly half (47%) say the primary purpose of genetic engineering is to produce changes in plants, compared with 30% who say its purpose is to produce changes in humans and 16% who say in animals. Seven in ten (70%) believe that the crossbreeding of plants is a form of genetic engineering, while only a quarter (24%) say they are two completely different things.

A majority of respondents perceive genetic engineering to be an evolutionary, rather than revolutionary, technology. Six in ten (59%) believe the science to be a result of gradual changes in technology, rather than the result of a breakthrough (cited by 33%).

Benfits Versus Risks

Overall, the sampled public is optimistic about the potential benefits of genetic engineering. The vast majority (87%) expect this science to produce benefits for people around the world. Two-thirds (67%) expect that they personally will benefit from genetic engineering.

However, the surveyed public expresses greater ambiguity when assessing possible risks. Over a third (36%) are unable to form concrete opinions about the benefits and risks. Four in ten (39%) describe genetic engineering as being risky, but most of these individuals (24%) say they expect benefits nevertheless. Only a quarter (25%) say genetic engineering is relatively safe.

Demographic factors do play a role in determining how an individual regards genetic engineering. Those who believe it to be safe and beneficial are more likely to be male, under 45, and better educated. They also tend to have a more positive attitude in general toward science and technology.

Call for Regulation

Both the experts and the surveyed public agree that genetic engineering should be regulated. Seventy percent (70%) of the sampled public say that limitations should be imposed on scientists regarding the kinds of genetic engineering research they should be allowed to conduct.

The surveyed public shows its strong trust in the scientific community by suggesting that scientists themselves be involved in the regulatory process. In fact, they suggest that several segments of society be involved. Among those groups most frequently cited for participating in the establishment of controls are the American Medical Association (70%), the scientists who conduct genetic engineering research (68%), the federal government (62%), and the people concerned with social ethics (60%).

Those experts interviewed would add another component to the regulatory process. They would like to see the public included. They are more aware of the potentially problematic issues raised by genetic engineering, and a majority of the experts would like to see regulation provided for by a broad coalition of people

from different disciplines, including scientists, ethicists, and lay people. In order for such a coalition to be possible, however, they point out that it is necessary to have an informed public, which is not the case today.

Two in three members of the surveyed public (66%) would like to see an international agreement regarding a common set of guidelines and limitations for genetic engineering scientists and companies around the world. Who should enforce these guidelines? Among those groups mentioned most frequently are an international group of scientists (77%) and the United Nations (65%). A large majority (78%) would also like to see the Soviet Union and its eastern bloc allies included in any such international agreement.

Need for Public Education

An overwhelming majority of the surveyed scientists and ethicists agreed that it is important to initiate an educational program to inform the public about some of the vital issues surrounding genetic engineering. How much does the public really need to know? As one geneticist explained, it isn't necessary for people to understand the nuts and bolts of genetic engineering, but they should be informed of the potential risks and benefits.

On the one hand, genetic engineering can offer a technological solution for certain biological or environmental problems. On the other hand, genetic engineering can appear threatening because it tampers with the "natural order."

Survey findings confirm what the interviewed scientists and ethicists around the country have expressed -- genetic engineering is not sufficiently understood by the public. The critical question is how can the public be educated. They suggest several possibilities -- from increased science reporting as a regular part of the news, to the inclusion of genetics as an explicit part of the school curriculum to achieve scientific literacy. The need for education is critical, given the rapid rate at which this technology is advancing. If the public is to play any role at all in helping to determine how much regulation there should be and which agencies should be involved, they will need a greater understanding of what genetic engineering is and what its potentials are.

INTRODUCTION

Over the past few decades, basic research in the biological sciences has begun to produce practical applications that can potentially affect the lives of millions. The year 1953 became a watershed for biology with the publication by Watson and Crick of the results of their breakthrough research on DNA. Soon thereafter, genetics research produced an explosion of new information about the fundamental biochemistry that controls the production and development of life. By the late 1970s, terms like "cloning" and "gene-splicing" had moved from the pages of science fiction novels to the front pages of our daily newspapers. A debate over the possible benefits and risks quickly ensued and continues to this day. As long as the technology of biology was confined to laboratory work on plants and animals, the stakes seemed relatively low. However, when biotechnology was applied to humans (with the first "test-tube" baby), and when scientists moved to introduce genetically altered bacteria into the environment, the public debate became more vigorous.

The term "biotechnology" is difficult to define because it is not a single field. Rather, the term encompasses a wide range of techniques and processes whose only common element is their basis in biology. They range from the mundane to the exotic. Examples include the fermentation that occurs in beer, wine, and bread via the action of microorganisms; farmers' selection of this year's best plants for next year's seed; horse and cattle breeding; recombinant DNA techniques for replacing specific genes in

bacteria so that they can clean up oil spills or reduce frost damage to strawberries; and the cloning of entire organisms (including humans) from a single cell.

The present research represents a search for mindsets or patterns of attitudes, beliefs,misconceptions, hopes, and fears about genetic engineering among Americans who know what it is. A previous effort to document the public's factual knowledge of the subject asked people to describe what genetic engineering is in their own words. The researchers found that "...about half the population are unable to even venture a guess, and many people who do give answers are clearly wrong, confusing genetic engineering with such things as test-tube babies or generic drugs."* Our own preliminary qualitative research also suggested that Americans don't know much about this topic in a technical sense.

How does one study people's attitudes toward a subject about which they have very little technical or specific knowledge? Our approach was to determine what people <u>think</u> genetic engineering is, what it does, and how it is done. For example, some people want strict limitations on the types of research that should be allowed, while others do not. Simply obtaining a tally of supporters and opponents of regulation tells us very little.

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* <u>The Cambridge Report</u>, First Quarter 1982, p. 164.

In our research we wanted to develop a better understanding of how Americans think about gentic engineering in terms of the following:

- Is it a radical, revolutionary new technology, or does it represent the accumulation of gradual changes?
- How safe or dangerous is it in comparison to other technologies (we chose agriculture and nuclear energy for generating electricity as points of comparison)?
- Do people expect more benefits for themselves or for other people around the world?
- To what extent is the public aware of any existing guidelines or limitations on research?
- Do people think there should be such guidelines and limitations? If so, who should determine those guidelines?
- How widespread is the reluctance to make moral judgments about what genetic engineers should be allowed to do?
- How far are people willing to go in allowing applications to humans if the potential gain is to cure a disease or potential disease (e.g.,a birth defect or hereditary disease)?

More information on the sources of data can be found in the methodology section of this report.

This report is organized as follows:

Chapter 1 analyzes people's perceptions of the scope or scale of technological change embodied in genetic engineering. It also discusses public perceptions of the risks and benefits of genetic engineering. In Chapter 2, we take up the issue of government

regulation of genetic engineering research, and the criteria Americans use to evaluate the need for regulation.

Ethics are the topic of Chapter 3. Since most people do not feel they have mastered the ethical or moral questions pertaining to genetic engineering, the issue is discussed in terms of specific allowable applications of the technology.

Chapter 4 compares attitudes toward three industries: agriculture, genetic engineering, and nuclear energy for generating electricity. It analyzes which of several attributes are most important to understanding how people evaluate the safety or danger of the three technologies.

Chapter 5 summarizes the experts' views on ethics and regulation in genetic engineering, and the need for an informed public. Chapter 6 provides an analysis of the two discussion groups.

Finally, the implications of this research are summarized in Chapter 7.

The data reported here were drawn from three sources:

Discussion Groups --

Two discussion groups were held at the outset of this study, one in Chicago and the other in New York. The participants were more highly educated than average, but otherwise the groups were balanced for sex, ethnicity, and age (with the exception that there were no senior citizens). The purpose was to obtain qualitative insights on how relatively well-informed Americans think and talk about the issues surrounding the biological

technologies.

Telephone Survey --

A sample of 613 Americans who had heard of genetic engineering were interviewed by telephone. A total initial pool of 1,006 was screened to find the 613 (61%) who had heard of genetic engineering. We felt it would be unproductive to ask people's opinions about a topic if they did not know what it was. Thus, the results reported here are based on the responses of the 613, who did not constitute a representative sample of Americans. Details on the telephone sample, along with sample demographics, can be found in the Methodology section.

Personal Interviews --

Interviews were conducted by telephone with 16 scientists in the fields of medicine, genetics, and biology, and with 13 individuals who specialize in dealing with general ethical issues and medical ethics in particular. Interviewees were asked to comment on some of the survey findings and to offer their own insights into the ethical, regulatory, and social issues raised by genetic engineering.

Perceptions of Genetic Engineering, Its Risks and Benefits

Awareness of Genetic Engineering

The survey began with a total pool of 1,006 potential respondents. Sixty-one percent (61%) of them had heard of the term genetic engineering. This is a surprisingly low level of awareness in light of the topic's wide exposure in the media. This group of 613 Americans comprised the sample for the remainder of the survey. All percentages reported here use this 61% as the response base.

Scope of Technological Changes

One perspective on the biotechnology industry is that many of its applications are simply technologically advanced ways of doing things that humans have been doing for centuries, even millenia. Breeding different strains of plants or animals by conventional means to improve wheat yields or produce faster horses or fatter cattle is an age-old technique which results in a change over time in the genetic characteristics of a species. This is often referred to as "artificial selection" to distinguish it from natural selection while putting it in the same general class of events.

Crossbreeding and similar techniques are, in this perspective, types of genetic engineering in the broadest sense of the term, and the advanced technology simply does more quickly and precisely what man and nature have been doing all along. In contrast, some might argue that there is a fundamental difference between "playing the odds" (crossbreeding) and "fixing the game"

(genetic engineering), with the latter seen as unnatural or "playing God."

People's perceptions about the scope of technological change represented by genetic engineering were assessed by asking the following three questions:

- Is traditional crossbreeding of plants and animals a type of genetic engineering, or is crossbreeding completely different?
- Is the purpose of most genetic engineering to produce changes in plants, or in animals, or in human beings?
- Is genetic engineering the result of technological breakthroughs or the result of gradual change in technology?

When these issues were tested in the survey, 70% considered crossbreeding to be a type of genetic engineering, while only 24% believe the two are completely different things. A plurality (47%) think the purpose of most genetic engineering is to produce changes in plants (47%), rather than animals (16%) or humans (30%). And a majority (59%) say that genetic engineering is a result of gradual changes in technology, while only a third (33%) think it is the result of technological breakthroughs (Table 1.1).

While there obviously have been some breakthroughs in the science, this pattern of responses suggests that many people view it as more of an evolutionary rather than revolutionary technology. For these people, it would seem that genetic engineering is simply a new road (albeit a less traveled one)

leading to the same old place.

TABLE 1.1

Crossbreeding of plants and animals in order to improve the breed has been going on for many centuries. Would you say this crossbreeding is a type of genetic engineering, or is crossbreeding completely different?

	%
Type of genetic engineering	70
Completely different	24
Don't know/No answer	7

Would you say the purpose of most genetic engineering is to produce changes in plants, or in animals, or in human beings?

	%
Plants	47
Animals	16
Human beings	30
Don't know/No answer	8

Do you think genetic engineering is the result of technological breakthroughs or a result of gradual changes in technological capability?

	%
Breakthrough	33
Gradual change	59
Don't know/No answer	8

Number of respondents (613)

Attitudes Toward Science and Technology

Attitudes toward genetic engineering do not exist in a vacuum. They occur in the context of attitudes toward science and technology as a whole. In order to place genetic engineering in its proper perspective, this study assessed attitudes towards

technology and science in general.

Most Americans sampled held positive attitudes toward science and technology. A majority believed the technological changes of the last 50 years have been beneficial rather than harmful, and 67% expected the technological changes in the next 10 years to be mostly beneficial, rather than harmful (Table 1.2).

TABLE 1.2

When you think about the technological changes of the last 50 years or so, how beneficial or harmful do you think they have been for society?

	%
Very beneficial	39
Somewhat beneficial	42
Somewhat harmful	11
Very harmful	4
Don't know/No answer	4

When you think about the technological changes that might occur in the next 10 years, do you think they will be mostly beneficial or mostly harmful?

	%
Mostly beneficial	67
Mostly harmful	24
Don't know/No answer	10

Number of respondents (613)

The sample does express some reservations about science. A majority (59%) agreed, at least moderately, that scientific discoveries make our lives change too fast, and 43% thought scientific discoveries break down ideas of right and wrong.

However, there was overwhelming agreement (86%) that science makes our lives healthier, easier, and more comfortable (Table 1.3).

TABLE 1.3:

Would you strongly agree, moderately agree, moderately disagree, or strongly disagree with the following statements:

"Scientific discoveries make our lives change too fast."

	%
Strongly agree	21
Moderately agree	38
Moderately disagree	27
Strongly disagree	14
Don't know/No answer	1

"Scientific discoveries tend to break down people's ideas of right and wrong."

	%
Strongly agree	16
Moderately agree	27
Moderately disagree	25
Strongly disagree	27
Don't know/No answer	4

"Scientific discoveries are making our lives healthier, easier, and more comfortable."

	%
Strongly agree	44
Moderately agree	42
Moderately disagree	9
Strongly disagree	4
Don't know/No answer	2

Number of respondents (613)

Attitudes on these five issues are all correlated with each other. People who hold positive attitudes on one tend to hold positive attitudes on the others. (Positive responses are that technology has been and will be beneficial, that science makes our lives healthier and easier but does not make our lives change too fast or break down ideas of right and wrong.)

Benefits of Genetic Engineering

Americans' optimism about science and technology carries over to their expectations of possible benefits from genetic engineering. More respondents believed that people around the world will benefit from genetic engineering than they will themselves. This is understandable since most of them tended to associate the technology more with plants and animals (i.e., agriculture) than with human applications. Drought-resistant crops will be more beneficial to people in Ethiopia, say, than to people in Kentucky.

About two-thirds (67%) of the survey respondents believed that they (or their families) will receive benefits from genetic engineering within their own lifetime, but a larger majority (87%) believed that people around the world will benefit from this technology (Table 1.4). The experts we interviewed were quite clear in stating that the public was being extremely optimistic concerning the benefits of genetic engineering.

TABLE 1.4

Do you expect that genetic engineering will provide any benefits in your lifetime to you personally or to your family?

Do you expect that genetic engineering will provide any benefits in your lifetime to people around the world?

	You or Family %	People around the World %
Yes	67	87
No	28	10
Don't know/No answer	5	4

Number of respondents (613)

Technological Risks

In order to provide a context for comparison for genetic engineering, survey respondents were asked to rate the safety/danger of agriculture and nuclear energy, as well as genetic engineering, on a 10-point scale.

Agriculture was rated as the safest of the three industries, although a substantial minority were concerned about the risks. Nuclear energy was rated as far more dangerous than safe. Genetic engineering was rated as somewhat more dangerous than safe, although it was considered as closer to agriculture in terms of danger than to nuclear energy. Agriculture was rated as more dangerous than safe by 26%, genetic engineering was so rated by 41%, and nuclear energy by 69% (Table 1.5).

TABLE 1.5

I would like you to think about three industries: agriculture, genetic engineering, and nuclear energy for generating electricity. On a scale of 1 to 10, where 1 means safe and 10 means dangerous, how would you rate:

	Agricultural Industry %	Genetic Engineering %	Nuclear Energy %
Safe (1 to 4)	52	26	15
Neutral (5)	20	29	15
Dangerous (6 to 10)	26	41	69
No opinion	2	4	1
Average rating	4.3	5.5	7.3

Number of respondents: (613)

"No opinion" responses were not included in calculation of means. The margin of error for average ratings is about 0.2.

By combining responses on the safe/dangerous scale with beliefs about receiving personal benefits in their lifetimes, the sample can be divided into five segments:

- Genetic engineering is relatively safe, personal benefits are expected (19% of the sample)
- Genetic engineering is risky, personal benefits expected (24% of the sample)
- Genetic engineering is relatively safe, personal benefits not expected (6% of the sample)
- Genetic engineering is risky, personal benefits not expected (15% of the sample)
- Neutral or no answer on safety or benefits (36% of the sample).

The "safe with benefits" segment can be interpreted as having the most pro- genetic engineering mindset, while the "risk without benefits" segment has the most anti- genetic engineering mindset. Together they comprise only about a third of the sample. The largest group (36%) were basically undecided. This suggests that even those Americans who have heard of genetic engineering have not yet formed concrete opinions on the subject.

This segmentation of the sample will be used throughout the report to assess how issues relate to the several risk/benefit mindsets.

The first question is whether the risk/benefit mindsets are related to the revolutionary/evolutionary way of thinking described earlier. The answer is that the relationship is both clear and strong.

Both the safe/beneficial and the risk/beneficial mindset segments had majorities saying that the purpose of genetic engineering is to produce changes in plants, rather than animals or humans, while a plurality of the safe/not beneficial and risk/not beneficial groups believed the primary application is to humans (Table 1.6).

TABLE 1.6

Would you say the purpose of most genetic engineering is to produce changes in plants, or in animals, or in human beings?

RISK VS. BENEFITS GROUPS

	Safe with Benefits %	Risk with Benefits %	Neutral, No Answer %	Safe, No Benefits %	Risk, No Benefits %
Plants	56	51	47	36	31
Animals	12	16	17	18	19
Human beings	30	25	26	41	40
Don't know/ No answer	3	8	11	5	11
Number of respondents	(115)	(146)	(218)	(39)	(95)

There was a similar split on whether crossbreeding is a type of genetic engineering, with the safe/beneficial and risk/beneficial segments more likely to agree with the equating of the two (Table 1.7). The critical factor in both cases was the expectation of benefits, rather than perceptions of safety or danger, and these benefits are associated with applications to plants and animals, rather than humans. Some who thought the primary application was to humans may believe the technology is not only devoid of benefits, but in fact threatening as well.

TABLE 1.7

Crossbreeding of plants and animals in order to improve the breeds has been going on for many centuries. Would you say this crossbreeding is a type of genetic engineering, or is crossbreeding completely different?

RISK VS. BENEFITS GROUPS

	Safe with Benefits %	Risk with Benefits %	Neutral, No Answer %	Safe, No Benefits %	Risk, No Benefits %
Type of genetic engineering	77	73	68	59	65
Something different	18	21	22	38	32
Don't know/No answer	4	6	10	3	3
Number of respondents	(115)	(146)	(218)	(39)	(95)

There were large differences in the demographic profiles of each of the risk/benefit segments. The safe/benefits segment was predominantly male (59% are men), younger (74% under 45 years), better educated (39% college graduates), and urban (30%) (Table 1.8). The risky/benefit segment was similar, except it had more women (61%), was slightly older, and suburban (36%) rather than urban.

The risk/no benefits segment was quite different: 68% were women, 37% were 45 years or older, 48% did not attend college at all, and 30% came from small towns. The safe/no benefits segment differed from the risk/no benefits segment in that there were fewer women (56%) and more urbanites (41%).

TABLE 1.8

DEMOGRAPHIC COMPARISONS

RISK VS. BENEFITS GROUPS

	Safe with Benefits %	Risk with Benefits %	Neutral, No Answer %	Safe, No Benefits %	Risk, No Benefits %
BY SEX:					
Male	59	39	41	44	32
Female	41	61	59	56	68
BY AGE:					
18 to 29 years	41	27	25	31	37
30 to 44 years	33	42	41	26	25
45 to 64 years	20	21	23	26	28
65 years or more	4	8	9	13	9
Refused	2	2	2	5	0
BY EDUCATION LEVEL:					
Some high school	7	5	14	5	8
High school graduate	27	27	33	38	40
Some college	25	30	24	28	23
College degree or higher	39	37	28	28	28
Refused	2	1	1	0	0
BY COMMUNITY SIZE:					
Urban (large city)	30	23	24	41	20
Suburban (small city)	24	36	33	28	32
Small town	25	21	28	15	36
Rural	17	21	13	13	13
Refused	3	0	2	3	0
Number of respondents	(115)	(146)	(218)	(39)	(95)

Briefly stated, the technology was viewed as safe by more men than women, and by more urbanites than those living in suburbs or small towns. It was seen as beneficial by those with higher educational levels, and by people living in rural areas.

It is worth noting here that on the safe/dangerous scales discussed earlier, agriculture was rated as significantly safer by urbanites and relatively more dangerous by those from rural areas. It may be that people who live day to day with the pesticide/herbicide cycle are less sanguine about the safety of modern American agriculture. The fact that rural people were more likely to see genetic engineering as beneficial may reflect a hope that the technology represents a way out of the vicious cycle of herbicides and pesticides.

Regulation of Genetic Engineering

In the mid-1970s, as a result of public controversy surrounding the techniques and possible applications of genetic engineering research, a group of scientists in the field met in California to develop voluntary guidelines for research. These guidelines were adopted by the National Institutes of Health in 1976. The NIH Recombinant DNA Advisory Committee has acted as a review board for research and field experiments since then. More recently, the U.S. Department of Agriculture and the Environmental Protection Agency have brought genetic engineering within their purview. And as will be noted later, some geneticists are not entirely happy with the maze of regulations.

Despite the publicity given to these guidelines, only 37% of Americans who had heard of genetic engineering were aware that any such guidelines or limitations exist. While this may seem a low figure, some experts we spoke with were surprised that the level of public awareness was as high as it was. Of those survey respondents who were aware of the existence of guidelines, most believed these guidelines had been set up by the federal government (47%) or one of its agencies such as the Environmental Protection Agency (13%), the Food and Drug Administration (16%), or the National Institutes of Health (8%). Only 21% identified scientific peer review committees as the source of the guidelines, while an additional 13% mentioned the American Medical Association (Table 2.1).

TABLE 2.1

As far as you know, are there any guidelines or limitations on the kinds of genetic engineering research that scientists can do?

	%
Yes	37
No	42
Don't know/No answer	21
Number of respondents	(613)

Who set up these guidelines?

	%
Federal government	47
Scientific peer review committees	21
Food and Drug Administration	16
American Medical Association	13
Environmental Protection Agency	13
National Institutes of Health	8
Other	1
Don't know/No answer	20
Number of respondents	(228)

Base: Respondents who were aware of guidelines.

While only a minority were aware of existing guidelines, 70% thought there should be strict limitations on the types of research allowed. This is in contrast with the professionals in the field, who were virtually unanimous in saying guidelines are needed. The public's choices for who should determine these limitations reflected their concerns about the technical and ethical difficulties involved. The American Medical Association was chosen by 70%, and 68% said the research scientists themselves should be involved. The federal government was selected by 62%. People's concerns about the ethical issues can

be seen in the fact that 60% believed that people concerned with social ethics should be included, while another 48% specifically cited religious leaders. Only a third thought that private sector companies should have a voice in determining regulations (Table 2.2).

TABLE 2.2

Do you think there should be strict limitations on the kinds of genetic engineering research that scientists can do, or should scientists be allowed to do what they think is best?

	%
Should be limitations	70
Let scientists do what is best	26
Don't know/No answer	4
Number of respondents (613)	

In your opinion, who should be involved in determining these limitations?

	%
The American Medical Association	70
Scientists who conduct genetic engineering research	68
The federal government	62
People concerned with social ethics	60
Religious leaders from a variety of faiths	42
Companies which produce genetically engineered products	34
Don't know/No answer	2
Number of respondents (426)	

Base: If there should be limitations.

International Regulations

Americans' concerns about the potentially global impact of genetic engineering can be seen from the fact that two-thirds believed there should be some international agreement to establish a common set of guidelines for all nations. Three-fourths (77%) of those who wanted an international agreement felt it should be enforced by an international group of scientists, rather than the United Nations (65%) or an international group of statesmen (46%) (Table 2.3).

TABLE 2.3

Do you think there should be an international agreement so that genetic engineering scientists and companies around the world would have to follow the same guidelines and limitations, or should each country be allowed to set its own standards?

	%
International agreement	66
Set own standards	31
Don't know/No answer	3
Number of respondents (613)	

Who should enforce these guidelines?

	Yes %	No %	Don't Know/ No Answer %
The United Nations	65	32	3
An international group of statesmen	46	46	8
An international group of scientists	77	20	3

Number of respondents (402)
Base: If there should be an international agreement.

Three-fourths of the sample (75%) believed the United States is among the world's leaders in the field of genetic engineering (Table 2.4). The Soviet Union was a clear second choice with 46%, followed by Japan (26%), Germany (21%), Great Britain (19%), and France (17%).

TABLE 2.4

As far as you know, which three or four countries lead the world in the field of genetic engineering?

	%
United States	75
Soviet Union	46
Japan	26
Germany	21
Great Britain	19
France	17
China	7
Other	19
Don't know/No answer	21
Number of respondents (613)	

The importance of the Soviet Union in world affairs generally, and its perceived prominence in the field of genetic engineering, led most people to believe the Soviet Union and other eastern bloc countries should be included in any international agreement on the subject. Of those who desired an international agreement, 87% would include the Soviet Union, and even among those who thought each country should decide its own rules, 59% would include the U.S.S.R. if there were an international agreement (Table 2.5).

TABLE 2.5

If there were an international agreement on guidelines for genetic engineering, do you think it should include the Soviet Union and other eastern bloc countries, or should the western countries reach an agreement on their own without the Soviet Union?

	Total	Should Be International Agreement	Let Each Country Decide
	%	%	%
Include U.S.S.R.	78	87	59
Western countries only	18	11	33
Don't know/No answer	4	1	8
Number of respondents	(613)	(402)	(191)

Among those who desire an international agreement, the U.S.S.R. would be included in the agreement by 93% of those who perceived it as a world leader in genetic engineering, and even 82% of those who did not think the U.S.S.R. is a leader in the field (Table 2.6).

TABLE 2.6

If there were an international agreement on guidelines for genetic engineering, do you think it should include the Soviet Union and other eastern bloc countries, or should the western countries reach an agreement on their own without the Soviet Union?

		BY THOSE WHO THINK U.S.S.R. IS A LEADER IN GENETIC ENGINEERING	
	Total %	Yes %	No %
Include U.S.S.R.	87	93	82
Western countries only	11	6	17
Don't know/No answer	1	1	2
Number of respondents	(402)	(196)	(206)

On a related issue, Americans felt that other countries around the world are not as careful about environmental matters as is the United States. Almost a third (31%) believed that western industrialized countries are less careful about environmental regulations compared to the U.S., while 19% thought other countries are more careful (Table 2.7).

TABLE 2.7

Compared to the United States, do you think other western industrialized countries are more careful about environmental regulations, less careful, or about the same?

	%
Other countries are more careful	19
Other countries are less careful	31
About the same	46
Don't know/No answer	5
Number of respondents (613)	

Similarly, about half (49%) thought that the Soviet Union and other eastern bloc countries are less careful about environmental regulation than the U.S., and only 9% said they are more careful (Table 2.8). This may be partly due to the lingering effects of the Chernobyl nuclear accident, but without pre-Chernobyl data, it is impossible to know with any degree of certainty.

Neither of these two questions was correlated with whether people wanted an international agreement or wanted the U.S.S.R. and its allies included in any agreement.

TABLE 2.8

Compared to the United States, do you think the Soviet Union and other eastern bloc countries are more careful about environmental regulations, less careful, or about the same?

	%
U.S.S.R. and eastern bloc countries are more careful	9
U.S.S.R. and eastern bloc countries are less careful	49
About the same	37
Don't know/No answer	5
Number of respondents (613)	

Benefits vs. Risks

Any discussion concerning the regulation or limitation of a technology assumes that there is some risk or danger involved. Chapter 1 showed that the perceived danger of genetic engineering is greater than that of agriculture, but less than the danger of

nuclear energy. On the other side of the equation are the potential benefits from a technology. Regulations need to be strong enough to reduce risk to an acceptable level, yet flexible enough to avoid stifling the industry and thereby eliminating the potential benefits that might accrue to society.

Of all the public's attitudes we examined, the one that has the most effect on the regulation question is the individual's assessment of risks and benefits. Desire for limitations on genetic engineering research is not related to the scope of technological change involved (i.e., is it applied to plants vs. humans, and is crossbreeding a type of genetic engineering), or the types of human applications allowed. The regulation issue is, therefore, not a question of the nature of genetic engineering or allowable applications. Deciding the regulation issue is influenced most strongly by each individual's assessment of the relative risks and potential benefits of genetic engineering.

A breakdown by risk/benefit segments of their views on regulation reveals several interesting differences. For domestic regulations, either the perception of safety or the expectations of benefits was sufficient to reduce support for placing limitations on genetic engineering research. Fewer than two-thirds of these groups supported limitations. However, limitations were advocated by 83% of those who saw the technology as risky and <u>not</u> likely to benefit them (Table 2.9).

On the related issue of who should determine what limitations should prevail, the "risk, no benefits" segments again stood out. They were least likely to want the involvement of the federal government, the American Medical Association, or scientists conducting research, but they were most likely to want involvement by religious leaders. Those who expected benefits (regardless of safety or risk) were the most desirous of involvement by the scientists themselves.

TABLE 2.9

Do you think there should be strict limitations on the kinds of genetic engineering research that scientists can do, or should scientists be allowed to do what they think is best?

	RISK VS. BENEFITS GROUPS				
	Safe with Benefits %	Risk with Benefits %	Neutral, No Answer %	Safe, No Benefits %	Risk, No Benefits %
Yes, limitations	63	65	71	64	83
Let scientists decide	36	32	22	28	14
Don't know/No answer	2	3	6	8	3
Number of respondents	(115)	(146)	(218)	(39)	(95)

Who should be involved in determining those limitations? Should it be:

American Medical Association	76	72	70	72	59
Scientists who conduct genetic engineering research	76	72	68	64	58
Federal government	69	67	63	56	49
People concerned with social ethics	60	63	56	52	65
Religious leaders from a variety of faiths	36	42	41	36	52
Companies which produce genetic engineering products	43	38	30	28	32
Don't know/No answer	1	3	1	8	1
Number of respondents	(72)	(95)	(155)	(25)	(79)

Base: Respondents who want limitations.

In the international arena, it was the combination of perceived safety and expected benefits that elicited the least support for guidelines and limitations (Table 2.10). The other four groups did not differ significantly in their support for an international agreement.

TABLE 2.10

Do you think there should be an international agreement so that genetic engineering scientists and companies around the world would have to follow the same guidelines and limitations, or should each country be allowed to set its own standards?

RISK VS. BENEFITS GROUPS

	Safe with Benefits %	Risk with Benefits %	Neutral, No Answer %	Safe, No Benefits %	Risk, No Benefits %
International agreement	57	66	67	69	71
Let each country decide	42	30	30	21	27
Don't know/No ans.	2	3	3	10	2
Number of respondents	(115)	(146)	(218)	(39)	(95)
Who should enforce those guidelines?					
United Nations	63	79	68	65	60
International group of statesmen	57	51	43	58	43
International group of scientists	83	85	81	65	81
Number of respondents	(65)	(97)	(146)	(27)	(67)

Base: Respondents who want international guidelines.

When it comes to enforcing international guidelines, the "risk, no benefits" group was least likely to assign that task to the United Nations or to a group of international statesmen. This group seemed least inclined to trust the judgment of politicians, either internationally or domestically.

These five segments differed sharply in their awareness of existing guidelines for genetic engineering research. The "risk, no benefits" group, which was most favorable to limitations, was least aware of existing guidelines (27% aware), while the "safe with benefits" group had a plurality (45%) aware of those guidelines (Table 2.11).

TABLE 2.11

As far as you know, are there any guidelines or limitations on the kinds of genetic engineering research that scientists can do?

RISK VS. BENEFITS GROUPS

	Safe with Benefits %	Risk with Benefits %	Neutral, No Answer %	Safe, No Benefits %	Risk, No Benefits %
Yes	45	39	36	38	27
No	37	41	37	51	57
Don't know/ No answer	17	20	27	10	16
Number of respondents	(115)	(146)	(218)	(39)	(95)

It is ironic that the segment which most wants limitations on research (the "risk, no benefit" segment) is least aware of their existence.

The Ethical Issue

Ethical issues were raised during the preliminary qualitative research which formed the first phase of this study. While people interviewed were quite vehement in stating a need for regulation, they were at a loss when it came to the form of regulation. Genetic engineering seems to be an important topic precisely because of the ethical and moral ramifications. The ability to alter life combined with human error or self-interest could permanently alter world ecology, human life, and sexual relationships. At the same time, very few people felt that they understood or had resolved the moral and ethical issues well enough to take a position on what kind of regulation there ought to be. In other words, they knew that ethics had to be considered, but they did not feel themselves to be competent judges of the issues at present.

The survey strongly confirmed this ethical quandary. Two-thirds of those who had heard of genetic engineering did not believe they understood these issues well enough to take a firm position on how genetic engineering should be regulated (Table 3.1), despite the fact that 70% believed limitations are needed. The experts in the field tended not to be surprised by the public's lack of moral decisiveness in light of the extraordinary complexity of the issues involved, and some of them were highly skeptical that the 29% who claim to have a grasp of the ethical/moral issues actually do.

TABLE 3.1

Would you say you personally understand the moral and ethical issues of genetic engineering well enough to take a firm position on how it should be regulated?

	%
Yes	29
No	66
Don't know/No answer	5
Number of respondents	(613)

A crucial finding was that the desire for limitations was not correlated with whether people felt they understood the moral issues. As we noted in the previous chapter, the desire for limitations on genetic engineering research was essentially a function of the individual's assessment of risks and benefits.

People who claimed to understand the moral and ethical issues of genetic engineering tended to have a less radical view of the technology. A majority (55%) of this group thought that genetic engineering was applied primarily to plants, compared to 44% of those who did not claim to understand the moral and ethical issues. Almost four-fifths (79%) of this group thought that crossbreeding of plants and animals is a type of genetic engineering, versus 67% of those who did not understand these issues (Table 3.2).

TABLE 3.2

Would you say the purpose of most genetic engineering is to produce changes in plants, or in animals, or in human beings?

Crossbreeding of plants and animals in order to improve the breeds has been going on for many centuries. Would you say this crossbreeding is a type of genetic engineering, or is crossbreeding completely different?

BY WHETHER UNDERSTAND THE MORAL AND ETHICAL ISSUES OF GENETIC ENGINEERING

	Yes	No	No Opinion
	%	%	%
Purpose of genetic engineering			
Plants	55	44	30
Animals	11	19	9
Human beings	29	29	39
Don't know/No answer	5	9	21
Is crossbreeding a type of genetic engineering?			
Type of genetic engineering	79	67	58
Something different	19	26	21
Don't know/No answer	2	7	21
Number of respondents	(177)	(403)	(33)

The implication is that some of those who claim to understand the ethics of genetic engineering can do so because, to them, it is a simpler issue, one that is not very different from traditional issues.

Given the moral uncertainties, a different approach was needed to determine where people would draw the line on genetic engineering applications. Respondents were asked if specific applications

should be allowed, rather than asking them to assess whether that application is moral or immoral, ethical or unethical. Human applications were deliberately chosen to see just how far people were willing to go.

Respondents tended to agree (by 67% to 23%) to allow inserting artificially altered genes into someone's body in order to cure a hereditary disease. A smaller majority (53% to 33%) would allow a similar technique applied to a fetus to treat a potential disease. Unexpectedly, a larger majority (75% to 16%) approved genetic manipulation of egg and sperm cells to prevent potential disease (Table 3.3).

TABLE 3.3

If scientists could cure a hereditary disease by inserting artificially altered genes into someone's body, should this be allowed?

	%
Yes	67
No	23
Don't know/No answer	10

If scientists could cure a potential disease by inserting artificially altered genes into a fetus, should this be allowed?

	%
Yes	53
No	33
Don't know/No answer	13

If scientists could prevent hereditary diseases by changing some genes in a woman's egg cells, or a man's sperm cells, so the disease can no longer be passed on to the next generation, should this be allowed?

	%
Yes	75
No	16
Don't know/No answer	10
Number of respondents	(613)

Our hypothesis was that the ability of a person to give consent to a procedure would be involved in determining whether it should be allowed. The lower approval rating for fetal procedures is consistent with this, but the findings on egg/sperm cells was not. It may be that egg/sperm cells are not thought of by many people as potential humans, but rather as merely cells (i.e., not human). Alternatively, respondents could have been focusing on

the presumed benefit contained in the question ("the disease can no longer be passed on to the next generation").

Most scientists and ethicists were surprised by such a high level of approval of human applications, even when it was emphasized to them that the percentages were based only on those who had heard of genetic engineering. They assumed, probably correctly, that the public did not fully understand the implications of what they were agreeing to, especially with regard to human egg and sperm cells.

When these responses were broken down by whether or not people understand the ethical and moral issues of genetic engineering, a consistent pattern emerged. Those who said they understood the moral issues were more likely to allow inserting altered genes in someone's body (75% vs. 64%), or in a fetus (62% vs. 50%), or in egg/sperm cells (80% vs. 73%) (Table 3.4.). This supports our contention that most of those who claimed to understand the moral issues saw the technology as inherently less threatening than do those who were in a moral quandary. Additional evidence for this interpretation comes from the risk assessment models described in Chapter 4.

TABLE 3.4

Allowing inserting altered genes in humans. (See Table 3.3 for wording of questions.)

	BY WHETHER UNDERSTAND THE MORAL AND ETHICAL ISSUES OF GENETIC ENGINEERING		
	Yes	No	No Opinion
	%	%	%
In someone's body?			
Yes	75	64	61
No	17	26	24
Don't know/No answer	8	10	15
In a fetus?			
Yes	62	50	55
No	29	36	24
Don't know/No answer	10	14	21
In egg/sperm cells?			
Yes	80	73	72
No	14	17	9
Don't know/No answer	7	10	19
Number of respondents	(177)	(403)	(33)

Beliefs about the benefits and risks of genetic engineering produced sharp divisions about applications of the technology to humans. People who viewed the technology as safe and beneficial overwhelmingly support genetic manipulation to cure disease in people (83% approve), in fetuses (72%), and in egg/sperm cells (88%). If the technology was seen as dangerous without benefits, approval ratings dropped to 55% for people, 39% for fetuses, and 66% for egg/sperm cells. The other three groups fell somewhere in the middle and were essentially equivalent (Table 3.5).

TABLE 3.5

Allowing inserting altered genes in humans. (See Table 3.3 for wording of questions.)

	RISK VS. BENEFITS GROUPS				
	Safe with Benefits	Risk with Benefits	Neutral, No Answer	Safe, No Benefits	Risk, No Benefits
	%	%	%	%	%
In someone's body?					
Yes	83	67	65	64	55
No	13	24	24	28	32
Don't know/No answer	4	9	11	8	14
In a fetus?					
Yes	72	49	51	59	39
No	19	36	35	26	46
Don't know/No answer	9	14	14	15	15
In egg/sperm cells?					
Yes	88	74	73	71	66
No	6	17	18	16	19
Don't know/No answer	6	9	9	13	15
Number of respondents	(115)	(146)	(218)	(39)	(95)

The Public's Assessment of Technological Risks

Discussion group participants spoke at length about the potential risks of genetic engineering. While they did not reach conclusions they talked about it in terms of being natural or artificial, understandable, controllable, local or global in its effects, and new and innovative vs. traditional ("tried and true").

Survey respondents were asked to use these adjectives, as well as safe vs. dangerous, to rate genetic engineering, agriculture, and nuclear energy on a 10-point scale. These ratings determine how genetic engineering compares with the other two industries, and were analyzed to see if perceptions of the relative safety or danger of these technologies can be understood in terms of these concepts.

On average, agriculture was rated as the safest of the three industries, as well as the most natural, understandable, controllable, and traditional (Table 4.1). Nuclear energy was rated the most dangerous, artificial, most global in its effects, and the least controllable. On average, genetic engineering was rated as closer to agriculture than to nuclear energy. While gentic engineering was considered similar to nuclear energy in terms of mysteriousness and level of artificiality, it was roughly tied with agriculture as least global in its effects (although all three industries were rated as more global than local in their effects). Genetic engineering was also considerd to be the most innovative of the three fields.

TABLE 4.1

I would like you to think about three industries: agriculture, genetic engineering, and nuclear energy for generating electricity. I am going to read a list of adjectives, and I would like you to rate how well they describe each of the three industries. On a scale of 1 to 10, where 1 means safe and 10 means dangerous, how would you rate:

	Average Rating
Agricultural industry	4.3
Genetic engineering	5.5
Nuclear energy	7.3

Where 1 means natural and 10 means artificial:

Agricultural industry	4.4
Genetic engineering	6.6
Nuclear energy	7.2

Where 1 means understandable and 10 means mysterious:

Agricultural industry	3.7
Genetic engineering	6.3
Nuclear energy	6.6

Where 1 means controllable and 10 means uncontrollable:

Agricultural industry	3.4
Genetic engineering	5.4
Nuclear energy	6.6

Where 1 means innovative and 10 means traditional:

Agricultural industry	5.5
Genetic engineering	3.9
Nuclear energy	4.2

Where 1 means a local effect and 10 means a global effect:

Agricultural industry	7.5
Genetic engineering	7.7
Nuclear energy	8.3

Number of respondents ranged from 585 to 606. "No opinion" responses were not included in calculation of means. The margin of error is about 0.2.

The issues in Table 4.1, together with a scale measuring overall attitude toward science and technology (derived from the data in Tables 1.2 and 1.3), were used to build a conceptual model of people's perceptions of the safety or danger of the three industries, using a technique called multiple regression analysis. This is essentially an equation with safety/danger ratings on one side and the remaining ratings on the other side in varying quantities. The different sizes of those quantities reflect the different levels of importance of each attitude in predicting ratings of safety or danger. The results are discussed here, and are presented in abbreviated form in Table 4.2. Details are contained in Appendix A.

Despite the diversity of these three industries, there were common themes in the ways people thought about and assessed the risks of the three technologies. The perception of controllability played a dominant role in evaluating whether a technology was safe or dangerous. This was especially true for nuclear energy, perhaps because of recent instances of loss of control in nuclear power plants.

Beliefs about safety and danger also related strongly to whether an industry was seen as natural or artificial. The more natural an industry was, the safer it was. Conversely, higher ratings of artificiality corresponded with higher ratings of danger. This factor was less important for genetic engineering than for the other two industries.

TABLE 4.2

Regression Analysis of the Safety or Danger of Three Industries.

The statistics presented in this table are estimates of the relative importance of several attributes in determining a person's perception of the safety of each industry. It should be read as follows:

The safety of (Industry) is related to (Attribute) to the extent indicated by (Weight).

Industry	Attribute	Weight
Agriculture	Natural	.27
	Controllable	.24
	Understandable	.10
	Positive attitude toward Science & Technology	.07
Genetic Engineering	Controllable	.28
	Natural	.19
	Understandable	.14
	Positive attitude toward Science & Technology	.12
	Local effects	.07
Nuclear Energy	Controllable	.37
	Natural	.32
	Local effects	.09
	Positive attitude toward Science & Technology	.07

Example interpretation: For the safety of nuclear energy, whether or not it is controllable is about four times as important (.37) as is whether its effects are local or global (.09).

Detailed analysis with complete statistics may be found in the Appendix A.

The third common theme was overall attitude toward science and technology, although it is far less important than the control and natural issues. People who view science and technology as

beneficial and not threatening are slightly more sanguine about the safety of all three industries.

There were two differences in how people viewed the safety or danger of agriculture, genetic engineering, and nuclear energy. First, opinions of the safety of nuclear energy did not depend on whether people understood it or not. This may explain why partisans of the nuclear issue have found that information programs have had very little effect on public opinion. In contrast, increasing the public's knowledge of genetic engineering may well influence attitudes about the safety or danger of the industry.

The second difference was that for genetic engineering and nuclear energy (but not for agriculture), safety depended to a small degree on local containment of effects. To the extent that these industries' effects are widespread, they are seen as slightly more dangerous.

These findings suggest that, in the minds of Americans, genetic engineering shares characteristics with both agriculture and nuclear energy, although it more closely resembles agriculture. For agriculture and genetic engineering, the issues relating to safety are more varied and more balanced in their relative importance. Nuclear energy, however, is set apart by the clear primacy of the controllable and natural dimensions. The idea of nuclear safety is much simpler, although the technical reality of safety may be more complex. This may reflect the fact that the

negative effects of uncontrolled nuclear energy have been witnessed, while the (potential) downside of genetic engineering has not materialized.

The Ethical Dimension of Risk Assessment

In the previous chapter, we tentatively concluded that people who claimed to understand the moral and ethical issues of genetic engineering viewed the technology as a simpler issue. This interpretation is supported by a reanalysis of the regression model for the safety of genetic engineering presented above. Separate models were constructed for those who say they understand ethical issues and for those who do not.

For those who understand the moral and ethical issues, the safety issue boils down to whether the technology can be controlled, influenced by their own positive or negative attitudes toward science and technology in general. Moreover, the model does a better job of accounting for beliefs about safety for this group.

In contrast, for those who do not understand the moral and ethical issues, no single issue dominates how they think about safety, and the model leaves more unexplained variation in their ratings of safety. Either they think about the issue along more dimensions (some of which were not captured in this survey), or they are so bewildered by the complexity that their ideas on the subject form a less coherent pattern (i.e., responses were more random) (Table 4.3).

The statistical details of all of these models are presented in Appendix A.

TABLE 4.3

Analysis of the Safety or Danger of Genetic Engineering.

BY WHETHER UNDERSTAND THE MORAL AND ETHICAL ISSUES OF GENETIC ENGINEERING

	Yes	No
	Weight	Weight
Controllable	.39	.19
Natural	.09*	.25
Understandable	.14**	.15
Positive attitude toward Science & Technology	.20	.06*
Local effects	.09*	.04*

* Not statistically significant.

** Statistical significance is marginal.

Scientists' and Ethicists' Views on the Social Issues of Genetic Engineering

Ethics and Morals

The scientists and ethicists we spoke with* held widely varying opinions of both the nature and extent of the ethical problems arising from the rapidly developing technologies of genetic engineering. The most serious ethical issues surrounded the use of gene therapy or research on human subjects. However, the ethical questions also overlapped with the roles of politics, capitalism, and our relationship with the natural environment.

The range of opinions among the experts can be seen in two opposing and extreme points of view. One scientist simply stated that there are no moral issues associated with genetic engineering. There was no danger in any of the experiments he had seen, so he saw no moral objections. At the other end of the range was a medical school ethicist who felt that, while the thorniest issues involved human reproduction, at a minimum any interference with the environment or exploiting of nature had ethical problems associated with it.

However, most points of view were more moderate. One bioethicist felt that, while ethical questions arose whenever innocent bystanders could be hurt, he "could not imagine anything intrinsically wrong with genetic engineering." For him, the ethical issue was essentially a weighing of costs and benefits, except for conflicts with articles of religious faith, where

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* See the methodology section for a list of those interviewed.

benefit/cost analysis simply cannot be applied. More typical was the view of a scientist who felt that the really substantive ethical issues arose when the technology was applied to humans. Genetic manipulation of plants and animals (especially farm animals) was an entirely different class of events. Since farm animals "are bred to be slaughtered anyway," the issue of how they are bred pales into insignificance.

Ethics in Human Applications

The medical applications of genetic engineering on humans provoked the greatest range of concerns. There was a broad consensus that the use of genetically altered bacteria to produce drugs presented no ethical problems. This is simply another means of producing the chemical reactions long in use by the pharmaceutical industry. The consensus began to break down when the discussion turned to gene therapy (introducing new genetic material into living tissue). A few experts said that as long as it is applied to medically relevant and immediate issues, gene therapy presents no ethical problems. That is, if someone is sick, do your best to cure him. Indeed, not trying to effect a cure is the unethical alternative. But others felt it was not so straightforward. For them, the ethical issue in gene therapy depended on 1) whether the disease is life-threatening and 2) whether there are alternative therapies available. Gene therapy should be used out of necessity, not mere convenience.

A critical issue is whether genetic changes will affect only the individual treated (if somatic cells are involved), or be passed

on to future generations (via changes in germ-line cells). One view was that altering the genetic structure of somatic cells presents no ethical problem, but that altering germ-line cells does because traits are passed on. One person said that even germ-line cell changes are acceptable as long as it is for the prevention of diseases (e.g.,hemophilia), but not if it is used for eugenics. The major problem with eugenics (the attempt to "improve" the species) is who decides what constitutes an improvement. Or, to put it another way, one man's "disease prevention" is another man's "population enhancement." Another felt that germ-line changes are the most dangerous and morally problematic. But still another said there is no ethical distinction at all between somatic and germ-line cells.

Ethics in Plant and Animal Applications

Several experts were concerned by the potentially negative influence of capitalism and international politics on the use or misuse of genetic engineering in agriculture. The basic issue was that the technology will be available only to those who can afford it, resulting in an increased concentration of wealth and power in relatively fewer hands. In the domestic arena, the high cost (at present) of genetic engineering technology may make it difficult or impossible for small farmers to compete with agribusinesses who employ genetic engineering to improve yields in crops or livestock. At its worst, a few giant firms in the food industry could determine the availability of certain types of foodstuffs. Only if the technology becomes cheaper will small farmers be able to compete.

Internationally, there was also an ethical problem involving agricultural applications. One bioethicist described RNA as "the universal capital of the planet." What if the wealthy capitalist countries take control of the enhanced DNA of the planet's food supply? These products could be used as political bargaining chips. For example, a wealthy nation might offer to trade drought-resistant crop seeds to a poor nation in exchange for military bases. Other experts saw this as unlikely due to the multiplicity of sources for genetic engineering technology.

Ethics and the Private Sector

A couple of people suggested that genetic engineering is more of an ethical problem in private sector research than it is in publicly-funded research, but for different reasons. One expert said that there will inevitably be a conflict between ethical considerations and the profit motive. That is, companies would engage in unethical research practices in order to increase profits. However, another felt there is no inherent conflict; the problem is that the private sector is more likely to monopolize information in the proprietary tradition of businesses rather than share it in the open tradition of science.

Regulating Genetic Engineering

The experts were virtually unanimous in agreeing that genetic engineering needs guidelines for research and a review process for applications. Some, however, felt that the present guidelines of the National Institutes of Health's Recombinant DNA Advisory Committee are too restrictive. The review process can

take too long, and certain areas of research are proscribed (public funds are not available for proscribed research). A few suggested that the NIH Advisory Committee be reconvened to redress these issues (one scientist complained that the present administration has not appointed anyone to the committee). A professor of philosophy and ethics opined that the current regulations assume that genetically engineered substances introduced into the environment will behave "artificially" rather than "naturally." That is, regulations assume these substances will have greater survivability (and therefore be more dangerous) than naturally occurring genetic mutations. While this expert felt this assumption may not be valid, our research on public opinion (see Chapter 6) indicates an interesting parallel between this regulatory assumption and public perceptions of genetic engineering.

Given that genetic engineering will have broad social and ethical ramifications, an obvious question is, "Who should have a say in determining regulations?" The majority viewpoint among the experts was that there should be a broad coalition of people from different disciplines (scientists, ethicists, and lay people) to have input into the regulations. A minority felt that government and the scientific community should have the major responsibility, with religious and lay ethicists in an advisory capacity, and the business community involved in the comment phase of writing regulations. One person noted that the private sector has been observing existing regulations even though it is not required by law to do so.

While specific regulations were not discussed, a few consistent themes did emerge. First, when humans are involved as subjects, the primary ethical and regulatory issues are consent and benefit to the individual involved. That is, the individual must be informed of the procedures involved (including risks, if any), he must give his consent, and the procedure must be likely to be of benefit.

A different set of standards applies to regulations and review process for procedures relating to plants and animals. Here the issue boils down to weighing costs and risks against likely benefits. The major problem seen by experts is that we don't understand enough about ecosystems for a reliable, precise cost/benefit analysis.

The Need for an Informed Public

By an overwhelming majority, the experts agreed that it is important that the public be informed and that a public education program is called for. The general feeling was that politics will get involved at various levels, and in a democracy politics starts with the voters. One person called for public debate on the grounds that on normative issues, expertise is very ambiguous. One scientist expressed doubts about the scientific community's competence to make ethical judgments for all of us. This was directly contradicted by an ethicist who rated scientists along with clergy as two of the most ethical groups he knew of. However, only a few were optimistic that such a program would succeed, while several expressed pessimism. One of the

pessimists commented that most medical students don't understand genetic engineering, so you can't reasonably expect the public to do so. One geneticist said that it isn't necessary for people to understand the nuts and bolts of genetic engineering, but they should be informed of the potential risks and benefits.

There were few substantive suggestions for how to go about educating the public. Some experts commented that a greater degree of coverage in the media, both electronic and print, could go a long way toward enhancing public understanding of genetic engineering. An alternative suggestion was that we concentrate our efforts on the young by introducing this and similar subjects as explicit parts of the school curriculum in order to achieve scientific literacy. This would require that the scientific community define what "scientific literacy" is.

A clergyman noted that in several states there are programs called health care forums. These are not state programs, but they are funded jointly by private and public sources. They involve presentations and talks at town meetings and the like by a large staff of well-educated professionals on the subject of health care. A similar program on genetic engineering might be well received, especially in those communities near research facilities.

It was also suggested that, whatever medium is used, it is important to educate the public on the limitations of scientific expertise, so that the public won't expect miracles next week.

The scientific and medical communities have a responsibility to "de-mythologize technology."

Finally, and contrarily, one ethicist stated that public ignorance is not a problem. Rather, the problem is with people who know just enough to be dangerous.

Discussion Group Results

The two group discussions were intended to provide a basic understanding of how Americans think about the biological technologies as a basis for designing the nationwide public survey. They were moderated by cultural anthropologists whose discipline relies on the techniques of observing and listening, rather than asking and probing. Anthropologists assume that attitudes toward genetic engineering, and any other technology, have their foundation in American culture. Genetic engineering is particularly interesting from this perspective because it embodies conflicting cultural tenets, in which, for example, the sacredness of the individual is set in opposition to trust in the benefits of technology.

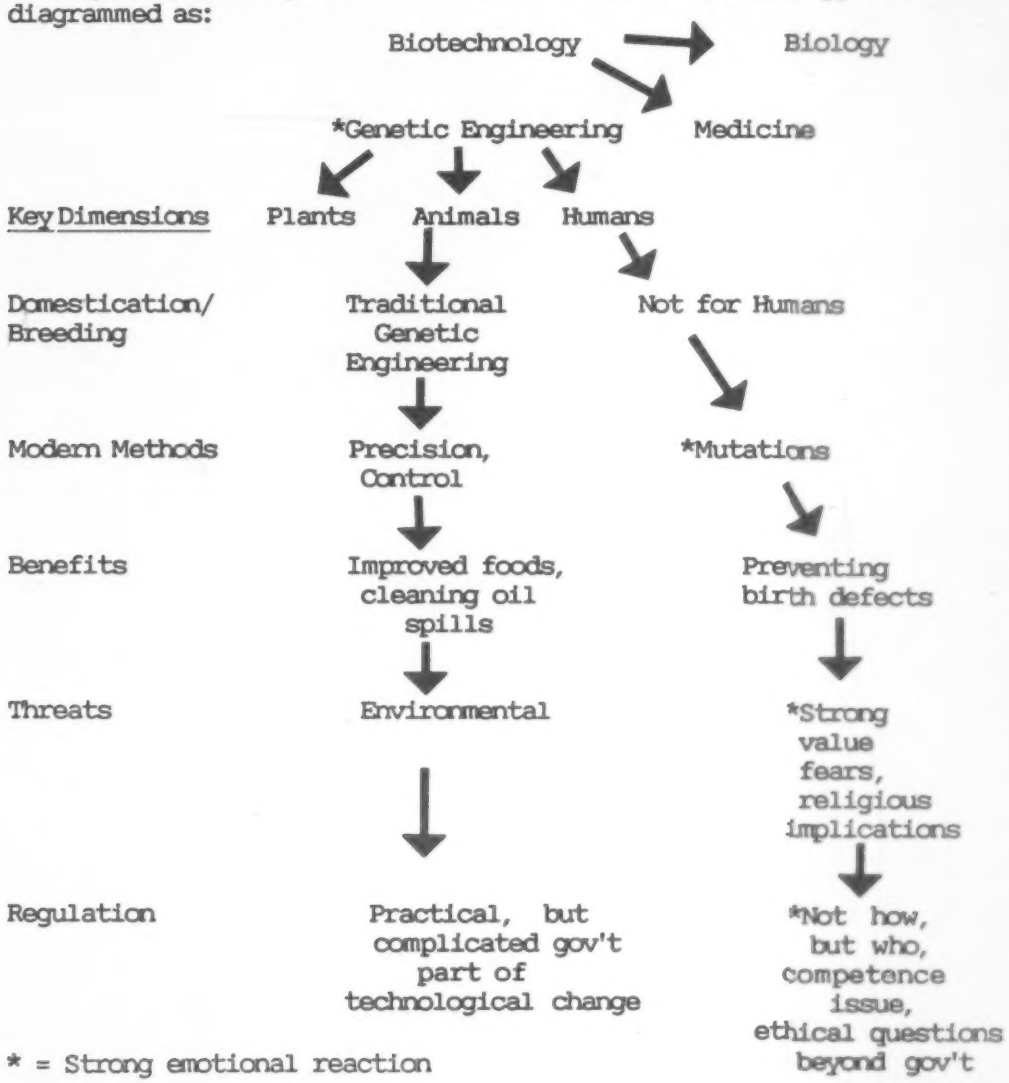
The aim of the discussion groups was to recreate, as nearly as possible within the constraints of a research project, a conversation that people might have when the subject turns to biotechnology. We were not looking for factual information necessarily -- perceptions and assumptions were equally valid as results for this stage of the research. Often, if people cannot put their finger on what something is, they will talk about it "as if" it were something else, or similar to something else. In the case of a highly technical subject like genetic engineering, that "something else" -- people's basis for comparison -- is the key to understanding how they think about a subject in the absence of specific knowledge.

The aim of these interviews was to understand genetic engineering

in the context of biotechnology as a symbol for Americans. What associations, what meanings do Americans feel are appropriate for biotechnology?

Biotechnology is a complex, multivocal symbol with a wide range of meanings, some more emotionally cathartic than others. This chapter will explore that range, focusing on those meanings that mattered most to interview participants.

As a guide, the symbolic dimensions of biotechnology can be diagrammed as:



The initial topic of discussion was biotechnology in general. The participants had varying definitions of biotechnology. The components included biology, medicine, health care, research, genes, and artificial organs, indicating the broad range of things subsumed under the heading of biotechnology. The major focus of the discussion, however, was genetic engineering, which included such things as gene splicing and cloning. Genetic engineering was a "buzzword"; it triggered a strong reaction and animated discussion. Medical and pharmaceutical applications (e.g., using genetically altered bacteria to produce human interferon) were put in the broader category of biotechnology, unless it was known that the process involved genes being "spliced" or "cloned," in which case it was genetic engineering. Participants classified genetic engineering into two important and separate arenas: plants and animals vs. humans.

We then explored symbolic differences between plants/animals and human genetic engineering in terms of key dimensions -- those dimensions that caused participants to view the human situation as unique, dangerous, and fear-inducing. The key dimensions are:

- Plant domestication/animal breeding -- seen as a traditional genetic engineering method,
- Modern techniques -- an improvement over traditional genetic engineering method,
- Benefits -- why is this important,
- Threat -- fears, concerns, doubts,
- Regulation -- feasibility, confidence in, role of government.

First, we will examine these dimensions for plants and animals, then for humans.

Genetic engineering of plants and animals was seen as a relatively non-controversial application of biotechnology. Most participants agreed that traditional methods of breeding cattle or wheat was "genetic engineering" of a sort. The difference between traditional methods in the field and modern methods in the laboratory was essentially one of precision/control and order of magnitude. Traditional breeding is a slow process, producing small incremental changes accumulated over generations. Much is left up to chance, since the desirable hereditary characteristics of a parent cannot be guaranteed to show up in offspring, while unwanted characteristics may do so. Genetic engineering was seen as more precise, since particular genetic characteristics (and no others, hopefully) could be altered en masse in a single generation or very few generations.

In fact, it is not that simple, precise, or controllable, as witnessed by recent attempts to raise genetically altered farm animals. These animals do indeed grow faster and larger than their parents, but they are beset by extraneous and debilitating characteristics such as difficulty walking. Nevertheless, the perception of genetic engineering as precise and controlled is a key factor in understanding both the hopes and fears of the public.

The major benefit of genetically engineering plants or animals was thought to be improved foods, especially drought- or frost-resistant crops. There was a vague awareness of frost fighting bacteria soon to be tested on potatoes or strawberries. (The actual word used by participants was "germ," not "bacteria.") Another benefit mentioned by some was the use of altered bacteria to help clean up oil spills.

On the downside, genetically engineered plants and animals presented a potential threat to the environment. While there was little specific fear of a "runaway microbe," participants knew that a great deal of care and control must be exerted to ensure the safety of an application of the technology. While the risk was seen as low, a mistake could be costly. As one participant put it, "Once it's in the (ecological) chain, it will be difficult to remove it." This and similar statements contain an implied assumption about the nature of genetically altered life forms. The fact that such a life form would need to be "removed" implies that it doesn't belong in the environment in the first place. In other words, it is an "artificial" intrusion into a "natural" environment. The need to isolate such a substance stems from an assumption that it will behave differently from a naturally occurring genetic mutation.

The application of genetic engineering to plants and animals presented very few ethical problems for the groups. They felt that some regulatory oversight was needed due to the

environmental considerations. However, the issue was essentially a practical one, rather than a moral one. In other words, genetic engineering was seen as one more major technological risk. It was evaluated using conceptual categories that were similar to those used to evaluate other technological and nuclear and environmental risks, such as natural vs. artificial, controlled vs. uncontrolled, and bounded vs. unbounded, but not right vs. wrong or moral vs. immoral.

Participants' attitudes shifted abruptly when the discussion turned to genetic engineering on human subjects. Since there is no precedent for breeding humans (except for horror movies and apocalyptic science fiction), the subject was inherently scary. Participants spoke of the potential for harm such as attempts to make "cookie-cutter" people or "the perfect human". They also acknowledged potential benefits such as preventing birth defects, but the major issue was, "Who controls it? Who decides what a defect is?"

The application of genetic engineering to humans raised major social, ethical, and religious issues. Participants did not take sides in the sense of declaring the technology or a likely application to be morally wrong or right. They could make moral judgments about extreme applications such as curing a sick child or breeding "supermen," but most applications were expected to be in the broad grey area of uncertainty. However, they did acknowledge that the technology raises questions about the nature of being human, of rights and individual choice. They were aware

that "decisions have to be made" even though they did not feel themselves to be competent to make them. The crux of the issue is who will make those decisions.

Thus the issue of regulation arose. Participants felt that regulation was clearly needed, but who would do the regulating and how would the criteria be determined? (There was only limited awareness of existing limits on research.) Both groups assumed the government would do the regulating, but this seemed to be based on inertia more than anything else. The government regulates other things, so it will probably regulate genetic engineering as well. In one discussion group, the issue of governmental competence was raised. Participants felt that government (bureaucrats) lacked both the technical and ethical expertise to do the job. This group felt that the American Medical Association (as a stand-in for the scientific community) and religious leaders (or people concerned with social ethics) should be involved in determining regulations.

Conclusions and Implications

The research reported here was an effort to understand Americans' beliefs, hopes and fears about genetic engineering. Our goal was not a simple tally of support or opposition on certain issues, but to understand the reasons why people responded as they did to specific issues. We assumed that attitudes toward genetic engineering, like any other technology, would have their foundation in the American culture which provides the underlying, and often unconscious, basis for stated beliefs and opinions.

Our preliminary research indicated that genetic engineering is of particular interest because it embodies conflicting cultural tenets. Our belief in a natural order, and the rightness of that natural order, is contrasted with our ability to alter nature at will. The sacredness of the individual is opposed to trust in the benefits of science and technology.

On the one hand, genetic engineering promises a technological panacea for biological or environmental problems. As with other medical technologies or discoveries, it promises improvements for human life. From this perspective, genetic engineering is just one more tool that enables humans to exercise control over the environment -- a hallmark of human activity.

On the other hand, genetic engineering threatens the sacredness of the individual. The perceived precision of genetic engineering threatens technological triumph over the individual in the form of clones, cookie-cutter people, and so forth. In

the extreme, the changes wrought by genetic engineering could alter the definition of human social or sexual relationships.

Our belief in the sacredness of the individual entails the concomitant belief that sociality, as it exists now, is natural, the way it is supposed to be. This sets up a tension with genetic engineering because it threatens to redefine humanness or question a belief in Natural Law, while at the same time it helps to cure childhood diseases or alleviate famine and other environmental problems.

From the geneticists' perspective, the public's fear may well be absurd but, they acknowledge, it makes some sense. "The overwhelming assumption is in a Newtonian principle of one-to-one correspondence." A change in a gene will lead to a precise, utterly predictable result. This assumed precision and predictability is the basis for both the hopes for improving life via agricultural, environmental, and medical applications, and the fears of undermining individuality via more ominous human applications. Achieving dominion over the earth is one thing. Achieving dominion over people is something else entirely.

There are four major conclusions to be drawn from this study of attitudes toward genetic engineering among Americans who have heard of it.

Despite widespread media attention to the most exotic and groundbreaking aspects of genetic engineering, most Americans who

have heard of it do not view genetic engineering as a radical new development. Asked to choose from statements representing competing points of view, Americans associate genetic engineering with applications to plants rather than humans, and these agricultural applications are equated with traditional methods of crossbreeding plants and animals. This new capability is seen as the result of gradual changes in technology rather than the result of breakthroughs.

Overall, the public is optimistic about potential benefits of genetic engineering, but at the same time they are aware that this technology carries risks. They were highly optimistic in expecting benefits within their lifetime for either themselves or their families, and even more optimistic in expecting benefits for people around the world.

While most people do not feel themelves to be competent judges of the moral and ethical implications of genetic engineering, they feel that ethics must be considered when developing guidelines for research. Nevertheless, large majorities approve certain human applications of the technology.

Seventy percent (70%) of the sample believed there should be guidelines or limitations on the kinds of genetic engineering research that scientists can do. (Only half as many were aware that some guidelines already exist.) There was strong support for involving medical professionals, scientists, and social ethicists, along with government agencies in determining

regulations for genetic engineering. Of more importance, perhaps, is the quarter of the sample who think research scientists should be allowed to do whatever they think is best. This indicates a high level of confidence in the scientific community, in view of the controversial nature of the subject.

Despite concerns about possible dangers in human applications, a sizable majority of the sample favored what amounts to gene therapy on humans for the purpose of curing disease. It seems likely that they do not fully comprehend the implications of such genetic alterations, especially as it applies to germ-line cells.

The data indicate a clear need for an objective, comprehensive, understandable program to educate the public about genetic engineering. Americans are concerned about the scientific and moral/ethical implications, but most do not have coherent sets of opinions about the issues. Unlike some other industries which carry technological risks (such as nuclear energy), genetic engineering has not yet induced most Americans to sort themselves into opposing camps with strongly held opinions.

The first issue that needs to be addressed concerns the nature of a genetically altered organism. Is it a cultivated form of "natural" life, or is it man-made, and therefore "unnatural"? This is a critical point in our society because our culture tends to assume that man-made substances do not belong in the natural environment. Indeed, artificial substances are usually thought of as polluting nature. On the other hand, genetic mutations

occur frequently in nature, caused by the effects of background radiation, viruses, random chance and the like. Is a genetically engineered mutation identical in essence, behavior, and effects to natural mutations? If so, it is "natural" for all intents and purposes. But this will be a difficult concept to get across to the public because of our cultural definitions of natural and artificial. Since these definitions are usually founded on assumptions, they often have no bearing on reality and may not yield in the face of evidence. For example, the monoculture of a wheat field is no more "natural" than the freeways of Los Angeles. Neither the crop nor the freeway could exist without a massive intervention by humans. Yet most Americans would probably view the wheat field as only a small step removed from wilderness.

A second goal of a public information program is to lower public expectations about potential benefits and probable risks. Exaggerated expectations in both areas stem from a common source: an overestimation of the geneticists' precision and control over the changes they can make in living organisms. If scientists could do whatever they wanted, they could improve crop yields overnight or produce "cookie-cutter" people. In fact, they can do neither, because they are limited to making marginal changes in the organisms they work with. Rather than inventing new DNA, they must work with the raw materials that nature provides. To a large degree, the public seems not to understand this.

The third point that must be raised concerns the ethical and moral questions arising from human applications of genetic engineering, especially gene therapy. Here, the purpose is not to inform the public (because there are no "scientific" answers to moral questions), but rather to stimulate public debate about these issues. The fundamental problem is a lack of consensus over what it means to be human. In fact, this debate has already begun. The abortion issue raises precisely this question, but in a narrowly defined arena. Genetics can be expected to exacerbate this conflict. Assuming people can be educated about genetics, will a public understanding of genetics undermine fundamental tenets of Western religions? Will genetic engineering catalyze a major confrontation between religion and the sciences in general?

In the future, we can expect genetic engineering to raise the question of "humanness" on a grand scale. It would be foolish to postpone this debate until the day a geneticist announces the ability to remove the genes for sickle-cell anemia, or improve the strength of our cardio-vascular system by borrowing DNA from other primates. It will take years, even decades, to reach a social and political consensus. The sooner we begin, the better.

METHODOLOGY

This report presents the findings of discussion groups and a telephone survey. Discussion group participants discussed genetic engineering (and other topics in biotechnology) in their own words. The transcripts were analyzed to determine what people think the issues are, and to formulate hypotheses for quantitative testing in the telephone survey. Most survey questions were chosen to reflect the language and priorities of the group discussion participants, rather than those of the researchers, the industry, or the industry's critics. Some questions contain factually incorrect, imprecise, or at least dubious propositions. This was intentional. The questionnaire reflects how ordinary people think about the issues, not how geneticists or biologists think about them.

The telephone survey was conducted among a randomly generated sample of 613 Americans, 18 years of age or older, living in private households in the continental United States. The raw frequencies reported here have a margin of error of $\pm$ 4%. It is a subset of data from a larger survey involving a sample of 1,006 Americans. This section describes the methodology for the larger sample.

Interviewing for the Novo Biotechnology survey was completed between April 10 and April 23, 1987 by members of the Research & Forecasts interviewing staff.

As required by the Code of Standards of the Council of American Survey Research Organizations, we maintain the anonymity of our respondents. No information will be released that in any way will reveal the identity of a respondent.

In order to ensure accuracy, Research & Forecasts has exercised its most advanced methods in the preparation of this report. Research & Forecasts cannot, however, assume responsibility for any use which is made of this information or any decisions based upon it.

Quality Control Measures

Quality control measures were applied in every phase of the Novo Biotechnology study:

- Interviewers were hired and trained in person, and their work checked regularly for accuracy and validity.
- Interviewers and interviewing supervisors were carefully briefed regarding the questionnaires and interviewing procedures.
- Since interviewing was conducted from a central location, the interviewers were constantly monitored.
- Many interviewees were called back by survey supervisors to verify that the questionnaires had been correctly filled out.
- Questionnaires were prepared for data processing by experienced coders, under the supervision of the survey director.
- Data processing was subject to rigorous internal checks designed to detect both machine and human error.

Reliability of Survey Results

Results of any sample are subject to sampling variation. The magnitude of the variation is measurable and is affected by the number of interviews and the percentage distribution.

The table below shows the possible sample variation that applies to percentage results reported in the Novo Biotechnology survey. The chances are 95 in 100 that a percentage result found in this study does not vary -- plus or minus -- by more than the indicated number of percentage points from the results that would be obtained if the interviews were conducted with all persons in the universe represented by the sample.

Size of Sample on Which Survey Result Is Based	Approximate Sampling Tolerances Applicable to Percentages At or Near These Levels				
	50/50	60/40	70/30	80/20	90/10
100	9.8	9.6	8.9	7.8	5.9
300	5.7	5.5	5.2	4.5	3.4
400	4.9	4.8	4.4	3.9	2.9
500	4.4	4.3	4.0	3.5	2.6
700	3.7	3.6	3.4	3.0	2.2
1000	3.1	3.0	2.8	2.5	1.9

How to use this table: Find the intersection between the sample size (for example, 1,000) and the approximate percentage distribution of the binomial in the sample (for example 80% said "yes," 20% said "no"). The number appearing at this intersection represents the estimated sampling error, at the 95% confidence level, expressed in percentage points (plus or minus--in this example, 2.5%). This percentage figure is the margin of error, which in a sample of 1,000 would never be greater than 3.1%.

Sampling

Respondents were reached by telephone from a sample of randomly generated telephone numbers provided by Survey Sampling, Inc., of Westport, Connecticut.

Random digit dialing is the most widely used sampling technique in the United States. This method provides an efficient, statistically valid way of obtaining representative samples of the general public at a reasonable cost.

Data Collection

Approximately 30 members of the Research & Forecasts data collection staff conducted interviews of the American public. Interviews took place on weeknights between the hours of 6 p.m. and 11 p.m. and on weekends from 12 noon to 8 p.m. After 9 p.m., only numbers from time zones other than the Eastern Standard Time zone were called.

In order to ensure that the respondents were a representative sample of Americans over the age of 18, every effort was made to reach and complete an interview with a qualified respondent at each number. Interviewers made one initial call and at least three callbacks to each telephone number that had neither yielded a completed interview nor been disqualified.

Overall, interviewers achieved a sample response rate of 41%, comparable to the rates reported by other professionals in the field of survey research. A complete breakdown of the response

rate appears below.

Response Rate *		
Completed Interviews	1,006	(41%)
Nonresponse[1]	1,438	(59%)
Refusals	1383	
Terminated interviews	55	
Total Potential Respondents	2,442	(100%)
Excluded from Sample[2]	2,507	
Callbacks	235	
Deaf/Language problems	97	
Disconnected	909	
Never answered	840	
Always busy	81	
Business/Government	323	
Not qualified[3]	22	
Total Number of Calls	4,949	

1 Nonresponses are calls during which the phone was answered at some point by a potentially qualified respondent, but interviews were not completed.

2 Lines that remained unanswered or busy for four consecutive attempts were assumed to be nonresidential numbers (phone booths, problem lines, businesses closed for the evening, etc.) and were excluded from response rate calculations.

3 Those who could not be interviewed because they were too young or not residents of the household reached were classified as "Not qualified."

* The computation of response rates for this study conforms to guidelines set by the Council of American Survey Research Organizations (CASRO).

The demographic characteristics of the sample who had heard of genetic engineering are shown below. Compared to U.S. Census data, this sample is younger, more highly educated, and has a larger proportion of women.

Respondent's age

	%
18 to 24 years	16
25 to 34 years	28
35 to 49 years	29
50 to 64 years	16
65 years or more	8
Refused	2

Last grade of school completed.

	%
8th grade or less	1
Some high school	8
High school graduate	32
Some college	26
College graduate or higher degree	33
Refused	1

Marital status

	%
Married	57
Widowed	5
Separated/Divorced	10
Single	27
Refused	1

Number of people living in household

	%
1 person	14
2 persons	30
3 or 4 persons	40
5 or more persons	15
Refused	1

Employment status

	%
Employed full-time	55
Employed part-time	11
In school	7
Retired	10
Unemployed	5
Homemaker	12
Refused	1

Ethnic or racial background

	%
White	85
Black	8
Hispanic	3
Asian	1
Other	2
Refused	1

Total household income before taxes for the past year

	%
Less than $10,000	8
$10,000 to $15,000	10
$15,001 to $20,000	11
$20,001 to $30,000	19
$30,001 to $40,000	15
More than $40,000	22
Refused	15

Population of respondent's community

	%
Urban (large city)	25
Suburban (small city)	31
Small town	26
Rural	16
Refused	1

Respondent's sex

	%
Male	43
Female	57

Interviews with Experts

Twenty-nine scientists and ethicists were interviewed, mostly by telephone. Their names and affiliations are shown below. One person asked that his name and affiliation be withheld.

Father Phillip Boyle	AssociateDirector, Health Care Ethics St. Louis University Medical Center
Father James Bresnahan	Ethics Committee Northwestern Memorial Hospital
Dr. Maryanne Brown	Albert Einstein College of Medicine
Dr. Jane Elizabeth Cooper	Department of Biology Pennsylvania State University
Dr. Bernard Davis	Harvard Medical School
Dr. Christopher Denny	Department of Pediatrics UCLA Medical School
Dr. H.T. Engelhardt	Department of Ethics Baylor Medical College
Dr. Richard C. Essenberg	Department of Biochemisty Oklahoma State University

Dr. John Fletcher	Chief of Bioethics Program National Institute of Health
Dr. Hugh Frank	Chairman of Ethics Committee UC San Diego Medical Center
Dr. Ulfert Hornemann	School of Pharmacy University of Wisconsin
Reverend Robert Jais	Chairman of Ethics Committee Northwestern Memorial Hospital
Dr. James F. Leary	Department of Pathology and Laboratory Medicine University of Rochester Medical Center
Dr. Sanford Leiken	Chairman, Institutional Ethics Forum Children's National Medical Center
Dr. Ronald Lewis	Department of Agronomy and Plant Pathology University of Minnesota
Dr. Wen-Hsiung Li	Department of Microbiology & Immunology University of Texas
Dr. Kenneth Luskey	Department of Molecular Genetics University of Texas
Dr. Mary Mahowald	Associate Professor Case Western Reserve Medical School University Hospital
Dr. John Mareno	George Washington University
Dr. Subhash Minoca	Department of Botany and Plant Pathology University of New Hampshire
Dr. Lawrence McCullough	Professor of Philosophy and Ethics Georgetown University Medical School
Dr. Robert McDaniel	Department of Plant Genetics University of Arizona
Dr. Thomas McElhinney	Associate Professor, Medical Ethics Hahnemann University
Dr. Joseph McInerny	University of Colorado
Dr. Angel Pellicer	New York University Medical School

Dr. Seymour Seigel	Jewish Theological Seminary
Jeffrey Weiss	Ph.D. candidate Northwestern University
Dr. Norton Zinder	Rockefeller University

APPENDIX A:
Regression Models of Technological Risk Assessment

Results of Multiple Regression Analysis

Chapter 4 describes the results of a set of multiple regression analyses using beliefs about the safety or danger of three industries as dependent variables, with attitudes about other attributes of the industries as independent predictor variables. The results were summarized in Table 4.2. They are presented in full on the following pages.

One predictor variable which was not descibed in full in the text was the composite scale of overall attitude toward science and technology. It is an additive index of the responses to the questions in Tables 1.2 and 1.3 (i.e., whether technology is beneficial or harmful, and agreement or disagreement with statements about science). For the questions having a 4-point scale of responses, the most positive was scored as +2, the next most positive as +1, the most negative as -2, and the next most negative as -1. For the question on whether technological changes in the next 10 years will be either beneficial or harmful ful, "beneficial" was scored as +1, and "harmful" as -1. In all cases, a non-response was scored as zero. Scores on the composite scale ranged from -7 to +9, with a mean of 3.5.

All analyses used stepwise regression with listwise deletion of missing data. The regression on agricultural safety/danger is presented in Equation 1, the one for nuclear energy in Equation 2, and the analysis for genetic engineering in Equation 3.

Equation 1

Dependent Variable. Is agriculture safe or dangerous

Number of cases after listwise deletion = 584

Multiple R	.48917
R Square	.23929
Adjusted R Square	.23403
Standard Error	2.17087

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	4	858.32294	214.58073
Residual	579	2728.63597	4.71267

F = 45.53273 Signif F = 0.0

Variables in the Equation

Variable	B	SE B	Beta	SE Beta	T	Sig T
N/A	.28671	.04178	.27488	.04005	6.863	.0000
C/U	.25363	.04317	.23614	.04020	5.875	.0000
U/M	.10101	.03853	.10374	.03957	2.622	.0090
S/T	-.04867	.02450	-.07286	.03668	-1.986	.0475
Constant	1.82234	.23338			7.809	.0000

Where:

N/A = Is agriculture Natural or Artificial
C/U = Is agriculture Controllable or Uncontrollable
U/M = Is agriculture Understandable or Mysterious
S/T = Overall attitude toward Science And Technology

Equation 2

Dependent Variable. Is nuclear energy safe or dangerous

Number of cases after listwise deletion = 578

Multiple R	.61514
R Square	.37840
Adjusted R Square	.37406
Standard Error	2.07724

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	4	1505.12008	376.28002
Residual	573	2472.45259	4.31493

F = 87.20428 Signif F = 0.0

Variables in the Equation

Variable	B	SE B	Beta	SE Beta	T	Sig T
C/U	.34818	.03457	.36754	.03650	10.070	.0000
N/A	.31380	.03558	.31733	.03598	8.819	.0000
L/G	.09093	.03572	.08728	.03429	2.546	.0112
S/T	-.04289	.02386	-.06093	.03389	-1.798	.0727
Constant	2.03061	.38238			5.310	.0000

Where:

C/U = Is nuclear energy Controllable or Uncontrollable
N/A = Is nuclear energy Natural or Artificial
L/G = Is nuclear energy Local or Global
S/T = Overall attitude toward Science and Technology

Equation 3

Dependent Variable. Is genetic engineering safe or dangerous

Number of cases after listwise deletion = 562

Multiple R	.52645
R Square	.27714
Adjusted R Square	.27064
Standard Error	1.91148

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	5	778.87600	155.77520
Residual	556	2031.47987	3.65374

F = 42.63444 Signif F = 0.0

Variables in the Equation

Variable	B	SE B	Beta	SE Beta	T	Sig T
C/U	.24323	.03480	.28233	.04039	6.990	.0000
N/A	.18471	.03837	.19194	.03987	4.814	.0000
U/M	.12376	.03511	.14131	.04009	3.525	.0005
S/T	-.06850	.02217	-.11533	.03732	-3.090	.0021
L/G	.06209	.03374	.06855	.03726	1.840	.0663
Constant	1.90086	.36310			5.235	.0000

Where:

C/U = Is genetic engineering Controllable or Uncontrollable
N/A = Is genetic engineering Natural or Artificial
U/M = Is genetic engineering Understandable or Mysterious
S/T = Overall attitude toward Science and Technology
L/G = Is genetic engineering Local or Global

Chapter 4 includes a brief discussion of a re-analysis of the regression on the safety or danger of genetic engineering. Separate models were produced for respondents who said they understood the ethical and moral issues of genetic engineering (Equation 4) and for those who do not (Equation 5).

Equation 4

Dependent Variable. Is genetic engineering safe or dangerous

Selecting only Cases for which Respondent DOES Understand the moral and ethical issues of genetic engineering.

Number of cases after listwise deletion = 168

Multiple R	.60733
R Square	.36885
Adjusted R Square	.34937
Standard Error	2.08595

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	5	411.93859	82.38772
Residual	162	704.89474	4.35120

F = 18.93447 Signif F = 0.0

Variables in the Equation

Variable	B	SE B	Beta	SE Beta	T	Sig T
C/U	.35984	.06436	.39428	.07052	5.591	.0000
N/A	.09534	.07113	.08939	.06669	1.340	.1820
U/M	.13199	.06874	.13584	.07074	1.920	.0566
S/T	-.12250	.04010	-.19955	.06532	-3.055	.0026
L/G	.09152	.06866	.08595	.06448	1.333	.1844
Constant	1.91540	.76245			2.512	.0130

Where:

C/U = Is genetic engineering Controllable or Uncontrollable
N/A = Is genetic engineering Natural or Artificial
U/M = Is genetic engineering Understandable or Mysterious
S/T = Overall attitude toward Science and Technology
L/G = Is genetic engineering Local or Global

Equation 5

Dependent Variable. Is genetic engineering safe or dangerous

Selecting only Cases for which Respondent DOES NOT Understand the moral and ethical issues of genetic engineering.

Number of cases after listwise deletion = 370

Multiple R	.48025
R Square	.23064
Adjusted R Square	.22008
Standard Error	1.83490

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	5	367.40361	73.48072
Residual	364	1225.53963	3.36687

F = 21.82466 Signif F = 0.0

Variables in the Equation

Variable	B	SE B	Beta	SE Beta	T	Sig T
C/U	.16422	.04419	.19278	.05188	3.716	.0002
N/A	.22589	.04806	.24745	.05264	4.700	.0000
U/M	.12652	.04356	.14976	.05155	2.905	.0039
S/T	-.03723	.02744	-.06460	.04762	-1.357	.1757
L/G	.02997	.03981	.03609	.04794	.753	.4520
Constant	2.12832	.42054			5.061	.0000

Where:

C/U = Is genetic engineering Controllable or Uncontrollable
N/A = Is genetic engineering Natural or Artificial
U/M = Is genetic engineering Understandable or Mysterious
S/T = Overall attitude toward Science and Technology
L/G = Is genetic engineering Local or Global

APPENDIX B:
Survey Questions and Responses

1. When you think about the technological changes of the last 50 years or so, how beneficial or harmful do you think they have been for society? Would you say...

very beneficial	36%
somewhat beneficial	42%
somewhat harmful	11%
very harmful	5%
no opinion	7%

2. When you think about the technological changes that might occur in the next 10 years, do you think they will be mostly beneficial or mostly harmful?

mostly beneficial	59%
mostly harmful	27%
no opinion	14%

3. Would you strongly agree, moderately agree, moderately disagree or strongly disagree with the following statements.

Scientific discoveries make our lives change too fast.

strongly agree	22%
moderately agree	38%
moderately disagree	24%
strongly disagree	12%
no opinion	3%

4. Scientific discoveries tend to break down people's ideas of right and wrong.

strongly agree	17%
moderately agree	29%
moderately disagree	26%
strongly disagree	22%
no opinion	6%

5. Scientific discoveries are making our lives healthier, easier, and more comfortable.

strongly agree	39%
moderately agree	44%
moderately disagree	10%
strongly disagree	4%
no opinion	3%

6. Have you ever heard of biotechnology?

yes	47%
no	51% [SKIP TO Q. 8]
DK/NA	2% [SKIP TO Q. 8]

7. Which of the following things do you associate with biotechnology? [Base: If heard of Biotechnology. N=474]

using bacteria to produce chemicals	yes	64%
	no	27%
	DK/NA	9%
making crops and animals more productive	yes	76%
	no	19%
	DK/NA	6%
diagnosing and treating disease	yes	87%
	no	8%
	DK/NA	6%
cleaning up industrial waste products	yes	70%
	no	22%
	DK/NA	9%

8. Have you ever heard of genetic engineering?

yes	61%
no	36% [SKIP TO Q. 34]
DK/NA	3% [SKIP TO Q. 34]

8A. Do you associate genetic engineering with biotechnology? [Base: If heard of Biotechnology and Genetic Engineering. N=365]

yes	73%
no	21%
DK/NA	6%

Questions 9 through 33 were asked only if respondent had heard of Genetic Engineering. N=613.

9. Recently, there have been a number of news reports about scientists and companies involved in new developments in the biological sciences. Please tell me if you remember hearing about any of the following things:

using special bacteria to help clean up oil spills

yes	60%
no	39%
DK/NA	2%

10. gene splicing

yes	79%
no	19%
DK/NA	3%

11. cloning, or making identical copies of plants, animals or people

yes	78%
no	20%
DK/NA	2%

12. artificially altering crops like wheat or potatoes to make them resistant to drought or frost

yes	64%
no	34%
DK/NA	2%

13A. using genetically altered bacteria to make medicines and drugs like insulin or interferon

yes	67%	
no	30%	[SKIP TO Q. 14]
DK/NA	3%	[SKIP TO Q. 14]

13B. Would you expect drugs produced by genetic engineering to be more expensive or less expensive than drugs produced in the traditional way?

more expensive	48%
less expensive	42%
no difference	3%

DK/NA	7%

14. Which of the following industries use genetic engineering?

	Yes	No	DK/NA
medical/health	88%	5%	7%
food processing	68%	19%	13%
farming	81%	12%	8%
drugs/pharmaceuticals	85%	9%	7%
oil/petroleum	48%	33%	20%

15. Would you say the purpose of most genetic engineering is to produce changes in plants, or in animals, or in human beings? [CHOOSE ONE ONLY]

plants	47%
animals	16%
human beings	30%
DK/NA	8%

16. Do you think genetic engineering is the result of technological breakthroughs or a result of gradual changes in technological capability?

Breakthrough	33%
Gradual change	59%
DK/NA	8%

16A Crossbreeding of plants and animals in order to improve the breeds has been going on for many centuries. Would you say this crossbreeding is a type of genetic engineering, or is crossbreeding completely different?

type of genetic engineering	70%
completely different	24%
DK/NA	7%

I would like you to think about three industries: agriculture, genetic engineering, and nuclear energy for generating electricity. I am going to read a list of adjectives, and I would like you to rate how well they describe each of the three industries:

17. On a scale of 1 to 10, where 1 means safe and 10 means dangerous, how would you rate: [AVERAGE RATING]

agricultural industry	4.3
genetic engineering	5.5
nuclear energy	7.3

18. On a scale of 1 to 10, where 1 means natural and 10 means artificial, how would you rate: [AVERAGE RATING]

agricultural industry	4.4
genetic engineering	6.6
nuclear energy	7.2

19. On a scale of 1 to 10, where 1 means understandable to you and 10 means mysterious, how would you rate: [AVERAGE RATING]

agricultural industry	3.7
genetic engineering	6.3
nuclear energy	6.6

20. On a scale of 1 to 10, where 1 means controllable and 10 means uncontrollable, how would you rate: [AVERAGE RATING]

agricultural industry	3.4
genetic engineering	5.4
nuclear energy	6.6

21. On a scale of 1 to 10, where 1 means innovative and 10 means traditional, how would you rate: [AVERAGE RATING]

agricultural industry	5.5
genetic engineering	3.9
nuclear energy	4.2

22. On a scale of 1 to 10, where 1 means it has a local effect and 10 means it has a global effect, how would you rate: [AVERAGE RATING]

agricultural industry	7.5
genetic engineering	7.7
nuclear energy	8.3

23. Do you expect that genetic engineering will provide any benefits in your lifetime to you personally, or to your family?

yes	67%
no	28%
DK/NA	5%

24. Do you expect that genetic engineering will provide any benefits in your lifetime to people around the world?

yes	87%
no	10%
DK/NA	4%

25A As far as you know, are there any guidelines or limitations on the kinds of genetic engineering research that scientists can do?

yes	37%	
no	42%	[SKIP TO Q. 26]
DK/NA	21%	[SKIP TO Q. 26]

25B Who set up those guidelines? [DO NOT READ LIST] [CHECK ALL THAT APPLY]

Environmental Protection Agency	13%
National Institute of Health	8%
Federal Government	47%
American Medical Association	13%
Food and Drug Administration	16%
scientific peer review committees	21%
other	1%
DK/NA	20%

26. Would you say you personally understand the moral and ethical issues of genetic engineering well enough to take a firm position on how it should be regulated?

yes	29%
no	66%
DK/NA	5%

27A Do you think there should be strict limitations on the kinds of genetic engineering research that scientists can do, or should scientists be allowed to do what they think is best?

Limitations	70%	
Do What is best	26%	[SKIP TO Q. 28]
No Opinion	4%	[SKIP TO Q. 28]

27B In your opinion, who should be involved in determining those limitations? Should it be (READ LIST; CHECK ALL THAT APPLY)

the Federal Government	62%
the American Medical Association	70%
religious leaders from a variety of faiths	42%
people concerned with social ethics	60%
scientists who conduct genetic engineering research	68%
companies which produce genetically engineered products	34%
no opinion	2%

28. As far as you know, which 3 or 4 countries lead the world in the field of genetic engineering?

United States	75%
Soviet Union	46%
Japan	26%
Germany	21%
Great Britain	19%
France	17%
China	7%
Other	19%
Don't Know	21%

29. Do you think there should be an international agreement so that genetic engineering scientists and companies around the world would have to follow the same guidelines and limitations, or should each country be allowed to set its own standards?

International agreement	66%	
Set own Standards	31%	[SKIP TO Q. 30A]
No opinion	3%	[SKIP TO Q. 30A]

30. Who should enforce those guidelines? Should it be:

	YES	NO	DK/NA
the United Nations	65%	32%	3%
an international group of statesmen	46%	46%	8%
an international group of scientists	77%	20%	3%

30A Compared to the United States, do you think other western industrialized countries are more careful about environmental regulations or less careful, or about the same?

other countries are more careful	19%
other countries are less careful	31%
about the same	46%
DK/NA	5%

30B If there were an international agreement on guidelines for genetic engineering, do you think it should include the Soviet Union and other eastern bloc countries, or should the western countries reach an agreement on their own without the Soviet Union?

include USSR	78%
western countries only	18%
DK/NA	4%

30C Compared to the United States, do you think the Soviet Union and other eastern bloc countries are more careful about environmental regulations or less careful, or about the same?

USSR and eastern bloc countries are more careful	9%	
USSR and eastern bloc countries are less careful	49%	
about the same		37%
DK/NA		5%

31. If scientists could cure a hereditary disease by inserting artificially altered genes into someone's body, should this be allowed?

yes	67%
no	23%
DK/NA	10%

32. If scientists could cure a potential disease by inserting artificially altered genes into a fetus, should this be allowed?

yes	53%
no	33%
DK/NA	13%

33. If scientists could prevent hereditary diseases by changing some genes in a woman's egg cells, or a man's sperm cells, so the disease can no longer be passed on to the next generation, should this be allowed?

yes	75%
no	16%
DK/NA	10%